Inlet Capacity Analysis for City of Alexandria Storm Sewer Capacity Analysis

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DATE: September 12, 2012

As part of the City of Alexandria Storm Sewer Capacity Analysis, the CH2M HILL team is developing hydrologic and hydraulic models of the storm sewer system for the City of Alexandria. During the model development, inlet capacity was to be modeled at up to 20 percent of the road inlets, lumping any upstream inlets into a single inlet of an equivalent capacity. The intent was to evaluate inlet capacity limitations, and limit flow into the system in areas where surface storage was occurring due to inlet limitations.

During modeling of the Four Mile Run priority area the modeling team discovered the xpswmm model was not generating reasonable results using the inlet capacity settings. The following types of results raised concerns:

- Surface ponding that lasted multiple days and generally longer than the model's three day simulation duration, for a 1-day design storm model run
- Water surface levels that rose and never receded even when the storm sewer system had capacity
- A second (smaller) peak in the storm sewer system hydrograph related to a large amount of surface flow entering into the system all at once.

Xpswmm allows the user to enter inlets with four options (maximum capacity, approach flow rating curve, approach depth rating curve, or HEC-22). Each of these options was evaluated and produced similar results. The issue was discussed with xpswmm technical support staff who indicated the inlet capacity option was intended to be used only in conjunction with an above ground open channel flow system (essentially representing the road cross-section) and does not function properly if there is not an open channel connected to the inlet. The xpswmm support staff provided two basic options for moving forward:

1. **Create a dual drainage system, explicitly modeling the gutter systems, which will allow the use of the inlet capacity options in xpswmm.**

    - Assumptions
        - Without the benefit of site specific evaluations of actual surface flow paths, it is assumed that there is a parallel gutter above every pipe, which is not always accurate (Figure 1).
        - The inverts of the gutters equate to the structure rims or the structure rims minus a consistent value. This assumption would not always be accurate. Given the assumption of creating a parallel gutter for every pipe, the gutters would connect all structure types (inlets, manholes, nodes, etc) structure rims would not necessarily follow a gutter line and would often be located in the middle of the road, and in sidewalks, medians, and yards.

  - All surface cross sections will have the same geometric components.
- Modeling and Results expected if a dual drainage system is represented in the model:
  - Each location will have both a subsurface and a surface link.
  - Any of the four xpswmm options for inlet capacity can be used including the HEC-22 method which calculates the capacity of the inlet using the geometry and slopes at the road surface.
  - The inlet capacity option can be used to produce a water surface profile at the surface of the street as well as in the storm sewer system.
  - The level of effort is significant, as the dual network would need to be created manually or a semi-automated procedure developed. Existing information is not in GIS other than current rim elevations.

2. Create a separate runoff point, and connect it to the collection system with a user-defined rating curve to represent the inlet capacity.

- Assumption
  - Without better information, this option would assume all inlets are in the same configuration (sag or at grade at some typical slope).
- Modeling and Results
  - Dummy nodes will be added at every catchment location so that an internal rating curve can be added before the runoff enters the storm sewer system.
  - Inlet capacity is modeled through a user input rating curve that is consistent throughout the system. The xpswmm options for inlet capacity cannot be used.
  - Water surface profiles along the length of the surface are not created.
  - The level of effort is significant, as the dummy nodes would need to be created manually or a semi-automated procedure developed and carefully QC'd.

Based on evaluation of these two options there is a significant level of effort that would go into adding inlet capacity into the xpswmm model explicitly. In addition, xpswmm has indicated the use of the inlet capacity option creates additional instabilities, which would lengthen what can already be long model runtimes (2 hours for Hooffs Run). Of these two options, the first would likely provide more valid results; especially if time were placed into identifying real surface flow paths. However, given the scope of this project, and the significant level of effort associated with either of these options, we recommend we remove inlet capacity as an element of the xpswmm model. This approach would assume that all of the runoff generated by a 10-year storm is able to enter the collection system, which would be a conservative evaluation of collection system capacity.

In lieu of explicitly modeling inlet capacity in the xpswmm model, we recommend a spreadsheet analysis to evaluate whether there is sufficient inlet capacity at each inflow location (See Table 1). This approach would assume a maximum inlet capacity of 3.25 cfs per 4-ft inlet, based on the capacity of an inlet in a sag location with the water surface elevation at the top of the inlet opening (Figure 2). The number of inlets and catch basins within each subcatchment would be counted and multiplied by the maximum inlet capacity to determine the inlet capacity of the subcatchment. This value would be compared to the runoff generated by xpswmm for that subcatchment to determine if there is sufficient inlet capacity. A table of these results would be provided in the modeling technical memorandum, similar to Table 1.

FIGURE 2
Assumed Inlet Geometry

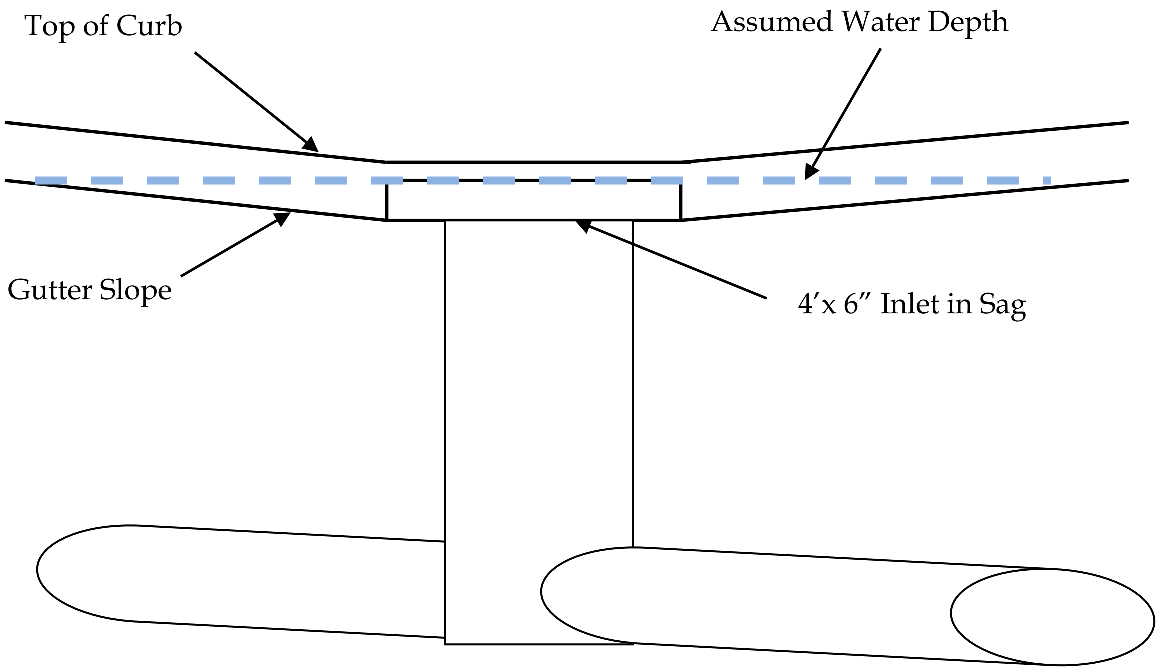

FIGURE 1
Plan view of some areas of Hooffs Run sewershed where storm pipe doesn't follow gutter (highlighted)

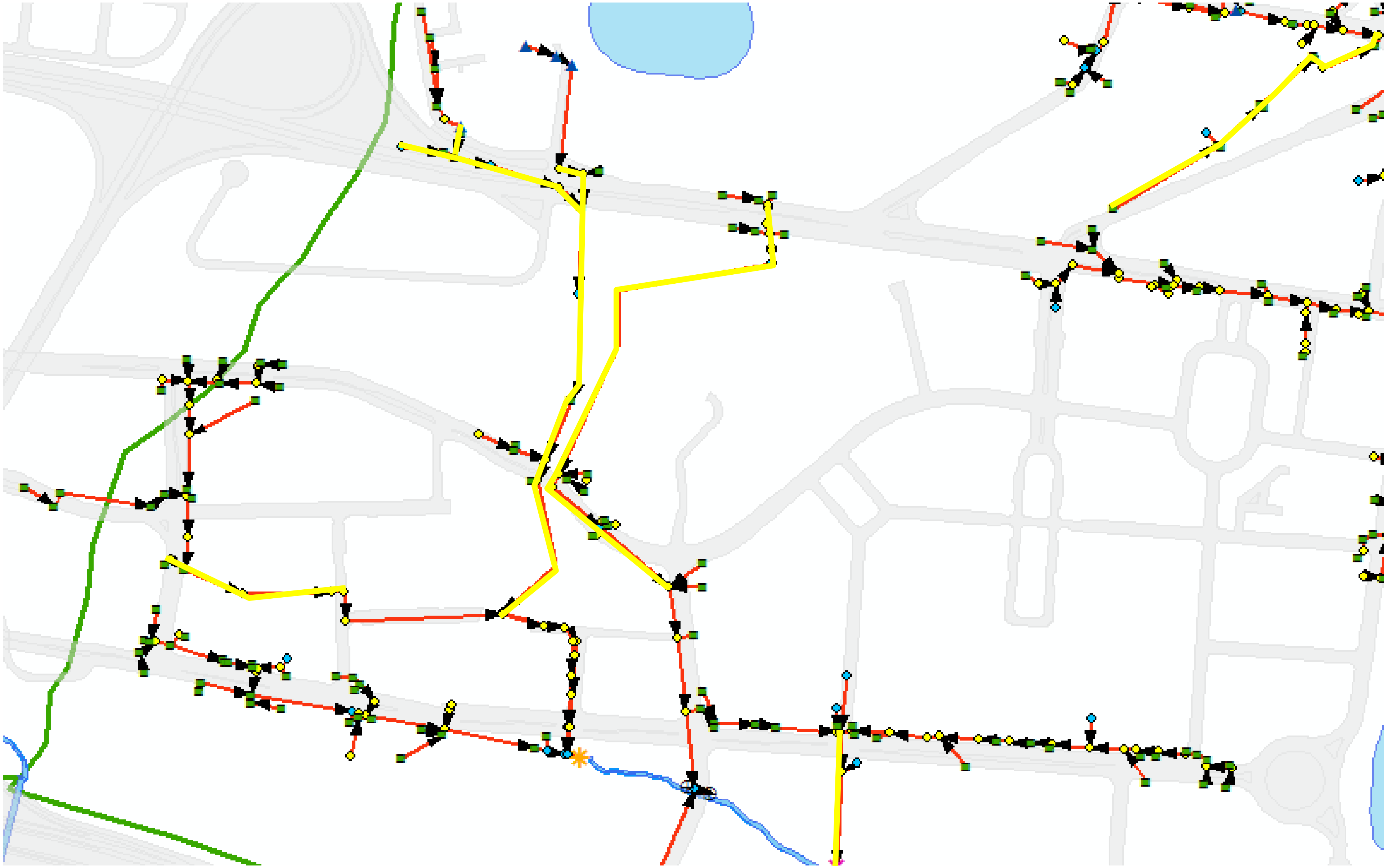

TABLE 1
Sample of Inlet Capacity Excel Table

Inlet Capacity Summary

Maximum Inlet Capacity (cfs) 3.25

Model Load Point	Total Drainage Area (ac)	Total Throat Count	Total Inlet Capacity (cfs)	Peak Runoff (cfs)	Capacity Summary
0001031ND	6.327	3	9.75	34.26	Insufficient Inlet Capacity
0001038ND	1.364	3	9.75	7.85	
000111CB	3.487	3	9.75	19.97	Insufficient Inlet Capacity
000123CB	2.221	3	9.75	11.51	Insufficient Inlet Capacity
000124CB	3.042	5	16.25	17.00	Insufficient Inlet Capacity
000133CB	2.423	3	9.75	13.43	Insufficient Inlet Capacity
000138CB	1.637	4	13	9.29	
000140CB	4.210	1	3.25	22.69	Insufficient Inlet Capacity
000142CB	1.492	3	9.75	8.48	
000149CB	1.073	4	13	6.07	
000152CB	1.900	4	13	10.45	
000158CB	4.990	3	9.75	27.43	Insufficient Inlet Capacity
000246SMH	1.379	2	6.5	7.78	Insufficient Inlet Capacity
000397CB	2.650	3	9.75	14.60	Insufficient Inlet Capacity
000398CB	4.390	8	26	24.44	
000401CB	2.454	9	29.25	13.63	
000403CB	1.570	5	16.25	8.80	
000409CB	0.842	4	13	4.72	
000410CB	1.198	6	19.5	6.65	
000414CB	1.617	4	13	8.84	
000415CB	1.271	4	13	7.02	
000423CB	2.061	7	22.75	11.40	
000424CB	1.193	2	6.5	6.63	Insufficient Inlet Capacity
000428CB	3.244	3	9.75	17.48	Insufficient Inlet Capacity
000454CB	1.839	5	16.25	10.21	
000456CB	4.576	4	13	24.98	Insufficient Inlet Capacity
000462CB	3.223	3	9.75	17.62	Insufficient Inlet Capacity
000470CB	0.888	5	16.25	5.01	
000472CB	4.504	5	16.25	24.04	Insufficient Inlet Capacity
000476CB	1.229	2	6.5	6.87	Insufficient Inlet Capacity
000481CB	0.759	1	3.25	4.27	Insufficient Inlet Capacity